

Traumatic scores validation for intensive care unit population from moldavian trauma center

Oleg Arnaut^{1,2}, Ion Grabovschi², Gheorghe Rojnovanu³

¹Valeriu Ghereg Department of Anesthesiology and Intensive Care; ²Department of Human Physiology and Biophysics; ³Nicolae Anestiadi Department of Surgery no.1, Nicolae Testemitanu State University of Medicine and Pharmacy, Chisinau, Republic of Moldova

Abstract

Introduction: Trauma, as it is shown by last statistical data from different countries, is among the leading causes of death and continues to increase his contribution to the overall mortality rate. The early recognition and improved management could be an instrument with a crucial role in decreasing trauma mortality rate. Attempts to predict the evolution course of the pathological conditions led to the different traumatic scores' conception. Nowadays, there are widely used a big list of elaborated scores according anatomical, physiological or mixed criteria. They were developed based on the distinct medical systems realities from different countries that could differ in many aspects from each other, inclusively, from the Moldavian one. Thus, it is necessary to identify the optimal one.

Objectives: Validation and comparative evaluation of the most common traumatic scores in conditions of a trauma center in the Republic of Moldova. **Materials and methods:** The current retrospective analytical research represent a part of a large retro-prospective cohort study. As a preliminary research, the 654 severe trauma patient's data were submitted for statistical analysis. They were calculated RTS, ISS, NISS, ASCOT, TRISS_{standard} and TRISS_{modified} scores to assess patient's survival rate. The prediction results were compared and statistically analyzed by logistic regression. **Results:** The mixed scores, ASCOT and TRISS_{modified}, has shown the maximal determination and discrimination abilities, the anatomical scores (ISS and NISS), unexpectedly, demonstrated the best calibration. **Conclusion:** The comparison of the proposed scores determined the ASCOT score as one with the highest accuracy in prediction in conditions of a trauma center from Republic of Moldova.

Keywords: Trauma, survival rate, predictive scores

Introduction

Trauma, with its different types and manifestations, always had an important role in determining mortality rate in different age categories. Nowadays, even if we can mention big progresses in prevention and treatment of different diseases, it is observed an increasing role of traumas in mortality causes, especially among young

Corresponding author: Ion Grabovschi, telephone (+373) 22 205 419, e-mail: ion.grabovschi@usmf.md
Universitatea de Stat de Medicină și Farmacie „Nicolae Testemitanu”
bd. Ștefan cel Mare și Sfânt, 165, Chișinău, Republica Moldova, MD-2004

Received: June 09, 2020; **Accepted:** July 21, 2020; **Published:** September 05, 2020

Citation: Arnaut O., Grabovschi I., Rojnovanu Ghe.: Traumatic scores validation for intensive care unit population from moldavian trauma center. Journal of Surgery [Jurnalul de chirurgie]. 2020; 16 (3): 185 – 194

Copyright: © 2020 Arnaut Oleg et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited

people. Data from US Center for Disease Control and Prevention classifies the trauma as the first cause of death of persons aged from 1 to 44 years and the third after cardiovascular diseases and neoplasms [1]. The World Health Organization (WHO) annually relates about tens of millions of traumas from which five million have lethal outcome (9% of all recorded deaths) that is approximately 1.7 times more than HIV/AIDS, tuberculosis and malaria together, being cause for 16% of all disabilities. WHO experts predict for following period an increased trauma mortality rate. By their estimations, in 2030 road accidents will be placed on 7th place (9th place in 2012), suicides on 16th place (15th place in 2012) and cat traumas on 17th place (21st place in 2012) in general lethality structure [2]. The same results are shown by similar studies in USA [3].

In Republic of Moldova, with some specifically features, can be observed the same tendency. As a proof of this fact could serve data of the National Bureau of Statistics of the Republic of Moldova. According to this source, for 2009-2018 period, trauma was the first death cause for persons aged between 1 and 44 years [4].

One instrument to reduce trauma lethality rate, especially for severe trauma or polytrauma, as main fatal conditions of this disease category, is the early recognition and improved management. As good is the ability to recognize and to understand the trauma severity, preventing fast patient status worsening on an apparent stable state, as high will be the survival rate [5].

Required optimization in this case can be achieved by using different trauma scores. They can be useful in triage decisions improvement, unexpected outcomes identification, audit filter generation/validation and the use as an objective basis for external and internal outcome comparison [6]. There are over 50 different traumatic scores that can be classified in [7]:

(I) Physiological scores, consider the clinical signs and affected body functional parameters without considering any anatomical aspects. Revised Trauma Score (RTS) is one of the most popular physiological score. RTS has inversely proportional value with the severity of trauma, it is calculated using the following model: $RTS = b_0 + b_1 \times GCS + b_2 \times SBP + b_3 \times RR$, where GCS – Glasgow Coma Scale (5 categories), SBP – systolic blood pressure (5 categories), RR – respiratory rate (5 categories), $b_0 = -3.5718$, $b_1 = 0.9368$, $b_2 = 0.7326$, $b_3 = 0.2908$. When RTS value is estimated it can be used in survival rate estimation through standard regression formula $P(\text{survival}) = e^{b/(1+e^b)}$, where $b = RTS$ [8].

(II) Anatomical scores are models that consider only the affected anatomical areas with no information regarding to physiological parameters. Among anatomical scores, Injury Severity Score (ISS) and New Injury Severity Score (NISS) are most popular models that were widely used in the last decades for the trauma severity evaluation. To estimate ISS, we have to use the following formula: $ISS = A^2 + B^2 + C^2$, where A, B, C are the highest Abbreviated Injury Scale (AIS) values present in each topographic region [5]. NISS in comparison with ISS, estimates trauma severity taking into account three maximal values of AIS [9], indifferent of the lesion's localization. For example, in case of trauma with four lesions $AIS_{\text{abdomen}} = 2$, $AIS_{\text{head and neck}} = 3$, $AIS_{\text{head}} = 3$ and $AIS_{\text{thorax}} = 5$, the NISS value will be higher ($NISS = 52 + 32 + 32 = 43$) versus ISS ($ISS = 52 + 32 + 22 = 38$). At the same time, according to the results obtained by clinicians from China, NISS is similar to ISS in predicting the outcome of the traumatic patients [10], having relative small discrimination ability. This could be explained by insufficient determination coefficient in equations that use NISS or ISS [11,12].

(III) Mixed scores are models that combine both, anatomical and physiological components. Trauma and Injury Severity Score (TRISS) is a score elaborated and widely used in North America. It derived from RTS and ISS, which, in turn, are calculated using the formulas mentioned above. After RTS and ISS estimation, the coefficient b from regression equation for survival rate ($P(\text{survival}) = e^b / (1 + e^b)$) is calculated in accordance with following formula: $b = b_0 + b_1 \times \text{RTS} + b_2 \times \text{ISS} + b_3 \times \text{Age Const}$, where Age Const is a binary value (0 if Age < 55, 1 if Age ≥ 55 [13]. Another popular mixed score is A Severity Characterization of Trauma (ASCOT). It takes into account Age, GCS value, systolic blood pressure and respiration rate to estimate RTS, ISS being calculated using AIS85 vocabulary and trauma mechanism (blunt or penetrating) [14].

However, as it was shown in a literature review of PubMed/Medline, Web of Science and EBSCO databases, we still lack a universal score, accepted by everyone [15]. In general, there are two ways to solve this problem and to implement a score in a medical system. First is to elaborate own scales based on local trauma registries, a well-known practice in western Europe [16]. The second, less expensive and more faster, could be done by comparative evaluation of existing trauma scores, identification of those with the maximal accuracy and predictive power with their further validation [17]. The literature showed a lot of comparative studies, when researcher tried to find optimal traumatic score for “their own” population or “their own” medical system, as usual the scores were adapted/modified in accordance to have better characteristics [13,18–23].

Actually, Moldavian medical system does not benefit any validate or elaborated common/national traumatic score. In daily clinical practice, medical staff uses different scores and it generate confusion when two trauma’s severity has to be compared. These facts, evidently, has a negative impact for traumatic patient’s evolution and outcomes, especially for Intensive Care Unit (ICU) trauma population [7].

Starting from this point, it was settled the aim of this research to make a validation and comparative

evaluation of most common traumatic scores, RTS, ISS, NISS, TRISS and ASCOT, with their further practical use for ICU severe trauma population from Moldavian trauma center (Institute of Emergency Medicine, Chisinau, Republic of Moldova).

Materials and Methods

The actual retrospective analytical research represents a part of a large retro-prospective cohort study that has the aim to improve the identification and prediction for severe trauma patients from Moldavian medical system. Nicolae Testemițanu State University of Medicine and Pharmacy (Chisinau, Republic of Moldova,) ethical committee approved the design of study (Protocol 33/46 from 16.12.2016).

There were considered first 1000 severe trauma patients consecutive admitted in Moldavian trauma center ICU (Institute of Emergency Medicine (IMU)), Chisinau, Republic of Moldova (period **January 2013 – November 2015**). The source for information was the electronic database of IMU with no personal information as first and second names, addresses, personal ID number, phone number etc. Research team members did not have direct access to IMU database.

The inclusion criteria were admission in ICU from IMU in first 24 hour after traumatic event, severe trauma (Injury Severity Score (ISS) ≥ 15 [24]), **age** ≥ 18 and blunt injury. The exclusion criteria were the age < 18, repetitive admission, burns, penetrating injury, incomplete data for trauma scores estimation or unusual analyzed variables values determined in preliminary dataset analysis, patients transferred to other institutions and mental disorders (senile or other deliriums) as reason for admission in ICU.

Finally, the 654 severe trauma patient’s data were submitted for statistical analysis. The criteria for trauma severity was the survival probability. It was estimated for each patient using six traumatic scores: RTS, ISS, NISS, ASCOT, TRISS_{standard} (variable age used as binary covariate, cut-off being 55 years) and TRISS_{modified} (variable age used as continuous covariate – the real age value). For both, standard and modified TRISS models, ISS

as anatomical component was used. In turn, ISS and NISS were estimated in accordance to the 2015 edition (last edition) of AIS vocabulary [9].

The coefficients for models' equations were estimated especially for examined population, this means validation of these traumatic scores and second, the models were compared in order to identify the most accurate score for survival rate prediction in ICU severe trauma population from Moldavian trauma center. The models without gender and age were adjusted for these parameters. In addition, the obtained tested scores' coefficients were used to generate the models (regression equation) to estimate the severe trauma survival probability from IMU ICU. Also, odds ratio (OR) and 95% confidence interval (95% CI) for OR were calculated.

To validate and to compare the models, logistic regression technique was used. For each model were estimated the following characteristics – *determination coefficient* (Nagelkerke R Square), *calibration* (Hosmer–Lemeshow test) and *discrimination abilities* (surface under the ROC curve). Considering a large number of developed models (six), the problem of multiple comparisons problem was solved by Bonferroni correction - the significance level of the models (α) being equal to $.05 / \text{number of developed models}$ ($\alpha = .05/6 = .008$).

Results and Discussions

First, all six trauma scoring systems (models) were tested in order to predict the severe trauma survival probability. Initially, for each model null hypothesis (the variables included in models are not able to predict the survival probability) was formulated and rejected by the results of Omnibus tests of model coefficients ($p < .001$, significance level α being $.008$). Thus, all examined models were able to predict the survival rate for severe trauma patients in conditions of IMU ICU. Second, the coefficients for validated regression models, covariates significance and covariates OR the same as 95% CI for OR were estimated (Table 1). Third, the comparative evaluation of tested models by determination, discrimination, calibration abilities were performed (Table 2). This analysis was completed by ROC curve presentation (Figure 1).

Single physiological score examined in this study, the RTS model, showed the significance ($p < .001$), coefficient for regression equation having positive value (.632). Increasing of RTS by 1 point was associated with 88% (OR = 1.881) rise of survival probability, the 95% confidence interval being relative narrow (OR 95% CI 1.578, 2.242). In the same time, another two covariates.

Table 1. Variables in equations for tested models

Table 1a. Variables in equation for RTS score								
	B	S.E.	Wald	df	Sig.	Exp(B)	95%CI for Exp(B)	
							Lower	Upper
Male gender	-.533	.220	5.875	1	.015	.587	.381	.903
Age, years	-.038	.005	54.011	1	.000	.963	.954	.973
RTS	.632	.090	49.729	1	.000	1.881	1.578	2.242
Constant	-1.675	.597	7.863	1	.005	.187		
Table 1b. Variables in equation for ISS score								
Male gender	-.363	.211	2.953	1	.086	.696	.460	1.052
Age, years	-.032	.005	43.948	1	.000	.969	.960	.978
ISS	-0.52	.012	19.799	1	.000	.949	.927	.971
Constant	3.026	.407	55.401	1	.000	20.622		
Table 1c. Variables in equation for NISS score								
Male gender	-.363	.210	2.997	1	.083	.696	.461	1.049
Age, years	-.031	.005	43.460	1	.000	.969	.960	.978
NISS	-0.34	.009	13.291	1	.000	.967	.949	.984
Constant	2.784	.393	50.249	1	.000	16.183		
Table 1d. Variables in equation for TRISS_{standard} score								
Male gender	-.366	.213	2.947	1	.086	.693	.456	1.053
ISS	-.030	.012	6.051	1	.014	.971	.948	.994
RTS	.530	.088	36.251	1	.000	1.699	1.430	2.019
Age, ≥55 years	-1.218	.184	43.803	1	.000	.296	.206	.424

Constant	-1.988	.666	8.906	1	.003	.137		
Table 1e. Variables in equation for TRISS _{modified} score								
Male gender	-.520	.221	5.535	1	.019	.595	.386	.917
Age, years	-.039	.005	57.187	1	.000	.961	.952	.971
ISS	-.035	.012	7.967	1	.005	.966	.943	.989
RTS	.578	.091	40.316	1	.000	1.783	1.492	2.132
Constant	-.662	.691	.917	1	.338	.516		
Table 1f. Variables in equation for ASCOT score								
Male gender	-.480	.222	4.673	1	.031	.619	.401	.956
Age, years	-.039	.005	57.187	1	.000	.961	.952	.971
RTS	.538	.092	34.474	1	.000	1.713	1.431	2.051
ASCOT	-.159	.041	15.045	1	.000	.853	.787	.924
Constant	-.208	.697	.090	1	.765	.812		

Logistic regression results. Constant - equation constant's value, B - regression coefficients, S.E. - standard errors, Wald - Wald statistics, df - degrees of freedom, Sig. - significance, Exp (B) - odds ratio values, 95% C.I. - 95% confidence interval for odds ratio.

RTS - Revised Trauma Score, ISS - Injury Severity Score, NISS - New Injury Severity Score, TRISS_{standard} - standard Trauma Injury Severity Score (variable age used as binary covariate, cut-off being 55 years), TRISS_{modified} - modified Trauma Injury Severity Score (variable age used as continuous covariate - the real age value), ASCOT - A Severity Characterization Of Trauma.

(male gender and age) had negative associations with dependent variable ($B_{\text{Male}} = -.533$ and $B_{\text{Age, years}} = -.038$). In case of RTS model, plus one year for Age variable Starting from estimated coefficients (Table 1a), survival rate probability (p) can be estimated using formula 1.

$$p = \frac{1}{1 + e^{1.675 - 0.632 \cdot \text{RTS} + 0.038 \cdot \text{Age} + 0.533 \cdot \text{Male gender}}} \quad (\text{formula 1})$$

where e (exponent) - constant equal to 2.71828.

Anatomical scores, ISS and NISS, both, showed no significance of male gender effect on survival probability ($p = .086$ and $p = .083$, respectively). Age ($B_{\text{ISS}} = -.032$ and $B_{\text{NISS}} = -.034$) and ISS/NISS ($B_{\text{ISS}} = -.52$ and $B_{\text{NISS}} = -.34$) had a negative sign in front of coefficient's value, both covariates were significant ($p < .001$). This, in turn, means their negative association with survival rate. When we have two patients the same age and they are different in

decreases the probability to survive by 4% (95% CI 3%, 5%), gender variable decreased it by 42% (95% CI 10, 62) (Table 1a).

accordance to ISS or NISS only one point, the survival probability patient with higher values is decreased by 5.1% (95% CI 2.9, 7.3) and 3.3% (95% CI 1.6, 5.1), respectively. The same exercise with Age covariate shows survival rate decreasing by 3.1% (95% CI 2.2, 4) for both ISS and NISS models (Table 1b and 1c). Regression equations in accordance to estimated coefficients had the following mathematical expressions, for ISS (formula 2) and NISS (formula 3) respectively:

$$p = \frac{1}{1 + e^{-3.026 + 0.52 \cdot \text{ISS} + 0.032 \cdot \text{Age} + 0.363 \cdot \text{Male gender}}} \quad (\text{formula 2})$$

$$p = \frac{1}{1 + e^{-2.784 + 0.34 \cdot \text{NISS} + 0.031 \cdot \text{Age} + 0.363 \cdot \text{Male gender}}} \quad (\text{formula 3})$$

where e (exponent) - constant equal to 2.71828.

The mixed models, $TRISS_{standard}$ (Table 1d), $TRISS_{modified}$ (Table 1e) and ASCOT score (Table 1f), used physiological component (RTS score), anatomical component (ISS for $TRISS_{standard}$ and $TRISS_{modified}$ or special algorithm for ASCOT), gender and age. Important to mention is the nonsignificant effect of gender for $TRISS_{standard}$ model ($p = .086$) and significance for $TRISS_{modified}$ model and ASCOT model ($p = .019$ and $p = .031$). According to last two models, male gender had negative effect on survival probability (reduces by 40.5% (95% CI 8.3, 61.4) and 38.1% (95% CI 4.4, 59.9). The effect of Age variable was similar for $TRISS_{modified}$ and ASCOT score ($B = -.039$), $p < .001$, plus one year decreases the survival probability by 3.9% (95% CI 2.9, 4.8). $TRISS_{modified}$ Age binary covariate (up to 55 and more than 55 years), having identical negative association. If a patient is older than 55 years, the probability for positive treatment result was decreased by 3.4 times (95% CI 2.4, 4.8) in comparison with younger one. Regarding to RTS component in all models, it was positive ($B = .530$ for $TRISS_{standard}$ score,

$B = .578$ for $TRISS_{modified}$ score and $B = .538$ for ASCOT score) in all cases survival probability being increased in correlation with RTS increasing by 69.9% (95% CI 43, 119), 78.3% (95% CI 49.2, 113.2) and 71.3% (95% CI 43.1, 105.1). Taking in account the large confidence intervals there are no data to state that it was difference among these models regarding to RTS coefficients. The anatomical component represented by ISS had similar effects in both standard and modified variants of $TRISS$. One point increase changed the dependent variable by 2.9% (95% CI .6, 5.2) or 3.4% (95% CI 1.1, 5.7). As a result, there is no difference in this aspect between mentioned models. The algorithm for ASCOT anatomical component showed negative coefficient ($B = -.159$), $OR = .853$ (95% CI .787, .924), this means that one scale point difference affects by 14.7% (95% CI 7.6, 22.3) the survival probability. Considering the obtained data, the following formulas were designed for $TRISS_{standard}$ (formula 4), $TRISS_{modified}$ (formula 5) and ASCOT (formula 6) respectively:

$$p = \frac{1}{1 + e^{1.988 + 1.218 \cdot Age - 0.53 \cdot RTS + 0.03 \cdot ISS + 0.366 \cdot Male\ gender}} \quad (\text{formula 4})$$

$$p = \frac{1}{1 + e^{0.662 - 0.578 \cdot RTS + 0.035 \cdot ISS + 0.039 \cdot Age + 0.52 \cdot Male\ gender}} \quad (\text{formula 5})$$

$$p = \frac{1}{1 + e^{0.208 + 0.159 \cdot ASCOT - 0.538 \cdot RTS + 0.039 \cdot Age + 0.48 \cdot Male\ gender}} \quad (\text{formula 6})$$

where e (exponent) – constant equal to 2.71828.

Validated models' comparative evaluation was performed in base of determination (Nagelkerke R Square), calibration (Hosmer and Lemeshow Test) and discrimination tested models' abilities (Table 2 and Figure 1). In accordance to Nagelkerke R Square parameter, ASCOT models had the maximal capacity to explain the survival rate dispersion, value being equal to 21.6%, followed by $TRISS_{modified}$ (20.3%) and RTS model (18.8%), anatomical scores having values little more than 10%. Calibration was optimal for anatomical models, ISS and NISS ($\chi^2=4.349$, $df=8$, $p=.824$ and $\chi^2=4.412$, $df=8$, $p=.818$) instead of poor model fit described in literature [25]. RTS

model had the worst calibration ($\chi^2=15.656$, $df=8$, $p=.048$). Discrimination analysis (Figure 1, Table 2) put again the ASCOT model on the first place according to the absolute value of surface under ROC curve, but the confidence intervals were intersected, that it is a sign of no reason to consider any model superior of inferior in comparison to another regarding to discriminant abilities for survival rate.

Upon the whole, the traumatic scores, validated in this research, evidently, need improvement, mixed models having good potential. The maximal value of determination coefficient was only 21.6% instead of 80%, when is considered that elaborated model has enough power to

“explain” the dependent variable. In addition, there were large confidence intervals for some variables (Male gender) and big standard error for adjusted coefficients (ISS, Male gender).

Table 2. Tested models’ comparative evaluation

Model	Determination (Nagelkerke R Square, %)	Calibration (Hosmer and Lemeshow Test)	Discrimination, Area under ROC curve (95% CI)
RTS	18.8	$\chi^2=15.656$, df=8, p=.048	.711 (.672, .750)
ISS	11.9	$\chi^2=4.349$, df=8, p=.824	.674 (.633, .715)
NISS	10.6	$\chi^2=4.412$, df=8, p=.818	.665 (.624, .707)
TRISS _{standard}	17	$\chi^2=10.031$, df=8, p=.263	.705 (.665, .745)
TRISS _{modified}	20.3	$\chi^2=8.824$, df=8, p=.357	.719 (.680, .757)
ASCOT	21.6	$\chi^2=9.171$, df=8, p=.328	.727 (.688, .765)

χ^2 - chi-square test of independence value, df- degree of freedom, p- statistical significance, 95% CI – 95% confidence interval for area under ROC curve.

RTS - Revised Trauma Score, ISS - Injury Severity Score, NISS - New Injury Severity Score, TRISS_{standard} - standard Trauma Injury Severity Score (variable age used as binary covariate, cut-off being 55 years), TRISS_{modified} - modified Trauma Injury Severity Score (variable age used as continuous covariate – the real age value), ASCOT - A Severity Characterization Of Trauma.

No far from mentioned problems, were situated validated model’s discriminant ability. Relative low surface under ROC curve, near the .7 or little more than .7, in condition when optimal value is closed to 1, sensibility and specificity being estimated less than 0.8 – the minimal value when the model has normal discriminative power and is able to determine both, survival and non-survival patients.

The identified problems can be solved by participant count increasing. Another solution is introduction as named efficient variables that affect the survival probability as, for example, comorbidities [26], biomarkers as INR [27] or components of proteases/antiproteases system [28], etc.

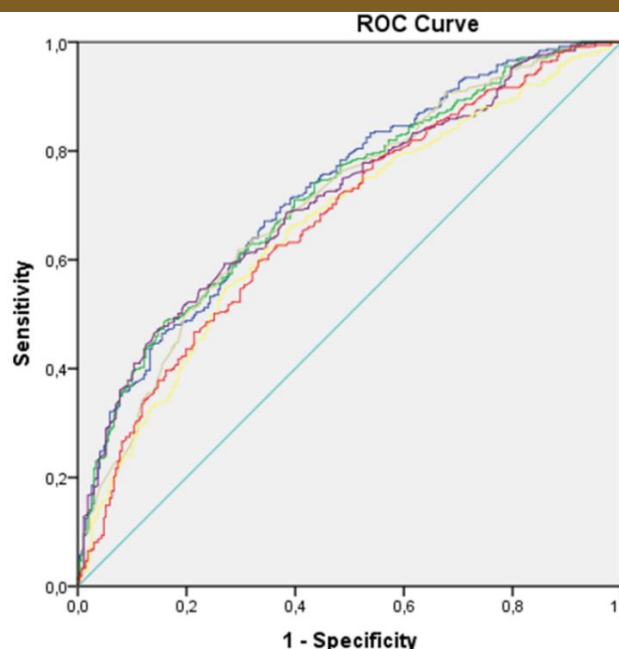


Figure 1. Area under ROC curve for ISS (red), NISS (yellow), RTS (brown), ASCOT (blue), TRISS_{modified} (green) and TRISS_{standard} (purple).

Conclusions

For the first time in condition of Moldavian medical system, six common traumatic scores were validated for ICU severe trauma population from IMU trauma center, coefficients for logistic regression equation were adjusted for examined population.

The validated models were compared among them to identify the most accurate score for survival prediction. The mixed scores, ASCOT and TRISS_{modified}, showed the maximal determination and discrimination abilities, anatomical scores (ISS and NISS), unexpectedly, demonstrated the best calibration.

However, the model's characteristics, especially determination, need improvement. It can be achieved through both, participant count increasing and new efficient variables identification. The updated results of tested models will be available after the whole electronic IMU database consideration for analysis.

Acknowledgments

This study was supported by Nicolae Testemitanu State University of Medicine and Pharmacy from Chisinau, Republic of Moldova. The trial was the author's initiative. The author is independent and takes responsibility for the integrity of the data and a accuracy of the data analysis

Conflict of Interest

Authors have no conflict of interest to disclose.

In this research, the fundamental ethical principles of research and the Helsinki Declaration were respected.

References

1. <https://www.cdc.gov/injury/wisqars/LeadingCauses.html>, Centers for Disease Control and Prevention and Control N C for I P and 2019 Ten Leading Causes of Death and Injury - PDFs|Injury Center|CDC Centers Dis. Control Prev.
2. https://www.who.int/violence_injury_prevention/media/news/2015/Injury_violence_facts_2014/en/ World Health Organization 2014 INJURIES VIOLENCE THE FACTS The magnitude and causes of injuries 20.
3. Rhee P, Joseph B, Pandit V, Aziz H, Vercruysse G,

- Kulvatunyou N and Friese R S 2014 Increasing trauma deaths in the United States *Ann. Surg.* **260** 13–21.
4. https://statbank.statistica.md/PxWeb/pxweb/ro/20%20Populatia%20si%20procese%20demografice/20%20Populatia%20si%20procese%20demografice_POP_POP040/POP041500.px/ Ratele mortalitatii pe Raioane/Regiuni, Ani si Principalele clase ale cauzelor de deces.
5. Lefering R 2012 Trauma scoring systems *Curr. Opin. Crit. Care* **18** 637–40
6. Lefering R 2002 Trauma score systems for quality assessment *Eur. J. Trauma* **28** 52–63.
7. Arnaut O, Croitoru D, Grabovschi I and Sandru S 2020 Trauma scoring systems *Mold. Med. J.* **63** 64–74.
8. Champion H R, Sacco W J, Copes W S, Gann D S, Gennarelli T A and Flanagan M E 1989 A revision of the trauma score *J. Trauma - Inj. Infect. Crit. Care* **29** 623–9.
9. <https://www.aaam.org/abbreviated-injury-scale-ais/> Association for the Advancement of Automotive Medicine 2015 The Abbreviated Injury Scale - 2015 Revision.
10. Deng Q, Tang B, Xue C, Liu Y, Liu X, Lv Y and Zhang L 2016 Comparison of the ability to predict mortality between the injury severity score and the new injury severity score: A meta-analysis *Int. J. Environ. Res. Public Health* **13**.
11. Arnaut O 2019 Survival predictive models in severe trauma patients transportation within Moldovan medical system *Mold. Med. J.* **62** 39–44.
12. Arnaut O 2020 The validation of New Injury Severity Score for severe and critical trauma patients *Mold. Med. J.* **63** 18–24
13. Domingues C de A, Coimbra R, Poggetti R S, Nogueira L de S and de Sousa R M C 2018 New Trauma and Injury Severity Score (TRISS) adjustments for survival prediction *World J. Emerg. Surg.* **13** 12.
14. Champion H R, Copes W S, Sacco W J, Lawnick M M, Bain L W, Gann D S, Gennarelli T, Mackenzie E and Schwaitzberg S 1990 A New Characterization of Injury Severity *J. Trauma - Inj. Infect. Crit. Care* **30** 539–46.
15. Stoica B, Paun S, Tanase I, Negoii I, Chiotoroiu A and Beuran M 2016 Probability of survival scores in different trauma registries: a systematic review. *Chirurgia (Bucur).* **111** 115–9.
16. Huber-Wagner S, Stegmaier J, Mathonia P, Paffrath T, Euler E, Mutschler W, Kanz K and Lefering R 2010 The sequential trauma score - a new instrument for the sequential mortality prediction in major trauma* *Eur. J. Med. Res.* **15** 185.
17. Gunning A C and Leenen L P H 2014 Applicability of the predictors of the historical trauma score in the present Dutch trauma population: Modelling the TRISS predictors *J. Trauma Acute Care Surg.* **77** 614–9.
18. Tan J H, Chor H, Tan L, Noh N A, Mohamad Y and Alwi R I 2017 Validation of the trauma mortality prediction scores from a Malaysian population **1–6**.
19. Chen W S, Lee S W H, Jamaluddin S and Wong C P 2017 Comparison of Trauma and Injury Severity Score model with alternative approach in outcome prediction in trauma using National Trauma Database in Malaysia *Trauma (United Kingdom)* **19** 103–12.
20. Chan C K O, Yau K K W and Cheung M T 2014 Trauma survival prediction in Asian population: A modification of TRISS to improve accuracy *Emerg. Med. J.* **31** 126–33.
21. Nassar A P, Mocelin A O, Nunes A L B, Giannini F P, Brauer L, Andrade F M and Dias C A 2012 Caution when using prognostic models: A prospective comparison of 3 recent prognostic models *J. Crit. Care* **27** 423.e1–423.e7.

22. Smith B P, Goldberg A J, Gaughan J P and Seamon M J 2015 A comparison of Injury Severity Score and New Injury Severity Score after penetrating trauma: A prospective analysis J. Trauma Acute Care Surg. 79 269–74.
23. Roy N, Gerdin M, Schneider E, Kizhakke Veetil D K, Khajanchi M, Kumar V, Saha M L, Dharap S, Gupta A, Tomson G and von Schreeb J. Validation of international trauma scoring systems in urban trauma centres in India Injury, 2016, 47, 2459–64.
24. Ali Ali B, Lefering R, Fortun Moral M and Belzunegui Otano T 2017 Epidemiological comparison between the Navarra Major Trauma Registry and the German Trauma Registry (TR-DGU®) Scand. J. Trauma. Resusc. Emerg. Med. 25 1–12.
25. Shi J, Shen J, Caupp S, Wang A, Nuss K E, Kenney B, Wheeler K K, Lu B and Xiang H 2018 A new weighted injury severity scoring system J. Trauma Acute Care Surg. 85 334–40.
26. Cook A, Osler T, Glance L, Lecky F, Bouamra O, Weddle J, Gross B, Ward J, Moore F O, Rogers F and Hosmer D 2018 Comparison of two prognostic models in trauma outcome Br. J. Surg. 105 513–9.
27. Kunitake R C, Kornblith L Z, Cohen M J and Callcut R A 2018 Trauma Early Mortality Prediction Tool (TEMPT) for assessing 28-day mortality Trauma Surg. Acute Care Open 3 e000131.
28. Arnaut O, Sandru S, Saulea A, Grabovschi I and Rojnoveanu G 2020 The Cathepsin D as a Potential Biomarker for Survival Rate in Polytrauma. Pilot Research IFMBE Proceedings Springer 77 703–5.